Arthroscopic repair of the subscapularis tendon: indications, limits and technical features

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Summary
The rationale to anatomically repair this tendon is to restore the functional biomechanics of the shoulder. Clinical and imaging assessment are required before undertaking arthroscopy. In this way, associated pathologies of the biceps and labrum may be successfully addressed. The arthroscopic repair of the tendon implies to use suture anchors and reinsert the tendon itself over the footprint. Results after arthroscopy are comparable to those observed after open procedures.

KEY WORDS: subscapularis, injury, arthroscopy, repair.

Introduction
Subscapularis tendon tears have been firstly described by Smith¹ and Codman². Hauser reported in 1954 the first case of surgical repair of the subscapularis tendon³. Isolated and associated subscapularis lesions are present in 2 to 10% of all the population, up to 20%⁴. Many surgical approaches may be use, but the standard repair which better restore its anatomy is arthroscopic⁵,⁶.

Pathogenesis
The etiology of sub-scapularis tendon tears is traumatic or degenerative. Traumatic tears are usually secondary to a forced external rotation or extension of the shoulder with the arm abducted. These tears are more frequent in young patients, rarely in elderly, as a consequence of a shoulder dislocation⁷,⁸. Adolescents are less frequently affected. In degenerative lesions, an associated sub-coracoid impingement may injury the anterosuperior portion of the rotator cuff, and involve the subscapularis tendon. When the coraco-humeral distance is reduced, observed on MRI or CT scans, other structures such as the long head of the biceps tendon and all the rotator cuff tendons may be differently involved. When this distance, which normally ranges from 8.7 mm to 11 mm, is lower than 5 mm, the risk that the subscapularis tendon is torn is high⁹,¹⁰. The coracoid impingement may be primary or acquired. It is primary, or idiopathic, when associated with congenital abnormalities of the coracoids such as the presence of a lateralized coracoid process¹¹, calcifications or ossifications of the subscapularis tendon, subscapularis muscle hypertrophy, and ganglion cysts¹². It may be secondary to displaced humeral or scapular fractures, non unions, posterior dislocation of the sterno-clavicular joint or iatrogenic, after surgery. Specifically, the Bristow/Latarjet and Trillat procedures change the biomechanics between coracoid and lesser tuberosity¹³; the posterior glenoid osteotomy may increase the anteversion of the glenoid neck and the coraco-glenoid angle, decreasing the coracohumeral distance¹⁴. The subcoracoid stenosis may also be consequence of a condition of minor anterior instability of the shoulder¹⁵, rotator cuff insufficiency, and sick scapula syndrome¹⁶. When an anterior acromioplasty is undertaken in patients with rotator cuff disfunction and narrow coraco-humeral distance, the antero-superior migration of the humeral head may predispose to the subcoracoid impingement syndrome¹⁷.

Finally, given the anatomical contiguity of the medial margin of the pulley and the subscapularis tendon insertion site, the subscapularis is torn in 63% of patients in whom the LHB is sub-luxated or dislocated⁹.

Tear classification
The subscapularis tendon tears may be classified as partial and complete, retracted and not retracted, superior (involving the upper third) and inferior (extended to the lower third 4-5). The classification system by Lafosse tendon distinguishes 5 types of insertional tears¹⁸. A type I tear is a simple erosion of the upper third of the tendon without any disconnection to the
The belly-press test starts with the arm beside the
scapularis tendon to rotate internally the shoulder,
and produce a pushing force against the abdomen.

The Napoleon test is a modified belly-press test, with
shoulder extended. This indicates a deficiency of the
ly is possible only with the elbow extension and
tra-laterally (tested by pushing on his elbows), or (B)

The lift-off test described by Gerber is performed
at the level of the lumbar spine, asking the patient to
place the hand of the affected side behind the back,
and the elbow ahead of the body. The patient is
asked to keep the position (forced internal rotation)
while the examiner attempts to pull the hand of the
patient away from the opposite shoulder by applying
a force in external rotation perpendicular to the fore-
arm. The test is positive when the patient cannot
keep the hand on the opposite shoulder or the
strength in internal rotation is impaired compared to
the opposite side. The test is negative when the
strength is comparable to the contra-lateral side, with
no pain. This diagnosis is supported when the exter-
nal rotation is pathologically increased.

Clinical assessment

On clinical assessment, the shoulder pain related to a
subscapularis tendon tear is more anterior compared to
the typical pain observed in patients with rotator cuff
tears. Weakness, mostly in internal rotation, and im-
paired function to touch the lumbar spine with the hand
may also be present. At times, is severe lesion, the
shoulder may be dislocated or sub-luxated anteriorly.

Lift-off, belly-press, Napoleon and bear-hug are specific
tests to assess the subscapularis tendon. Barh et
al. have reported that the bear-hug test has the high-
est sensitivity (60%), followed by the belly-press (40%),
Napoleon (25%); and lift-off test (17.6%). On the con-
trary, all the tests are highly specific (lift-off test 100%;
Napoleon test 97.3%; belly-press test 97.3%; bear-hug
test 91.7%). All these tests allow to diagnose a partial
tear in 30% of cases. More than 50% of tendon thick-
ness is torn when the Napoleon test is positive; more
than 75% when the lift-off test is positive.

The examiner should assess any internal rotation defi-
cency (less than 90°) related to an excessive tension
of the posterior -superior aspect of the capsule. In such
instances, all tests may be positive (false-positive) as the
a condition of limited internal rotation may mimic a
loss of strength of the subscapularis tendon.

The lift-off test described by Gerber is performed
placing the hand of the affected side behind the back,
at the level of the lumbar spine, asking the patient to
rotate the arm internally and to lift the hand from the
back, posteriorly. It is positive when the patient is not
able to raise the hand or if this movement is positive
only with the elbow extended. This test has limited
value in clinical practice as many conditions may not
allow to reach this position because of pain and limit-
ed range of motion of the shoulder.

The belly-press test starts with the arm beside the
body and the elbow flexed to 90°. The patient is
asked to press the hand against the belly with the
shoulder rotated internally. The test is considered
positive (A) if the pressing force is weaker than con-
tra-laterally (tested by pushing on his elbows), or (B)
if the pressing movement of the hand against the bel-
y is possible only with the elbow extension and
shoulder extended. This indicates a deficiency of the
scapularis tendon to rotate internally the shoulder,
and produce a pushing force against the abdomen.
The Napoleon test is a modified belly-press test, with
the hand lying on the abdomen, in the same position
which Napoleon Bonaparte used to be portrayed. The
test is negative, or normal, if the patient is able to press
his hand against the belly with the wrist in straight posi-
tion; it is positive when the patient is able to push the
belly with the wrist flexed to 90°, or 30° to 60°.

The bear-hug test is performed with the palm of the
hand of the affected side on the opposite shoulder,
the fingers extended, and the elbow ahead of the
body with the shoulder slightly flexed. The patient is
asked to keep the position (forced internal rotation)
while the examiner attempts to pull the hand of the
patient away from the opposite shoulder by applying
a force in external rotation perpendicular to the fore-
arm. The test is positive when the patient cannot
keep the hand on the opposite shoulder or the
strength in internal rotation is impaired compared to
the opposite side. The test is negative when the
strength is comparable to the contra-lateral side, with
no pain. This diagnosis is supported when the exter-
nal rotation is pathologically increased.

Imaging

Ultrasound (US) is less reliable than MRI. US is pre-
ferred to assess the tendon repaired after shoulder
arthroscopy. Arthro-MRI provides higher diagnostic
reliability compared to conventional MRI in patients
with subscapularis tendon tears, with 40 to 100% sensi-
tivity. An indirect sign, often associated with par-
tral subscapularis tears, is a medial dislocation of the
long head of the biceps.

Fatty degeneration (fatty infiltration) is a negative prog-
nostic factor for full functional recovery of the shoul-
der. The percentage of fatty infiltration predictive of
success after cuff repair is lower than 75%.

Tung et al. have reported that only 31% of subscapu-
laris tears confirmed at arthroscopy had been preoper-
atively on MRI. On the other hand, arthro-MRI can be
better assess both supraspinatus and infraspinosus
tears, accounting for 71% to 100% sensitivity. Given
the poor sensitivity of conventional MRI (36%) to diag-
nose subscapularis tendon tears, and the higher sensi-
tivity after contrast injection, MRI and arthro-MRI have
been compared in patients with tears involving more
than 30% of the subscapularis tendon thickness. By
considering arthroscopy as standard assessment of
these lesion, it has been shown low increase of sensi-
tivity of arthro-MRI (40 vs 36%) in patients undergoing
treatment and tendons undergoing arthroscopic repair of subscapularis
tendon. Repair is important to restore not only the in-
ternal rotation of the shoulder but also a dynamic an-
terior stabilization of the joint provided by a fine bal-
ance of pairs of forces. In addition, other studies
highlighted that the integrity of the subscapularis ten-
don plays a key role to reduce recurrences of rotator

Indications to arthroscopic repair

Burkhart and Tehrany reported the first series of pa-
tients undergoing arthroscopic repair of subscapularis
tendon. Repair is important to restore not only the in-
ternal rotation of the shoulder but also a dynamic an-
terior stabilization of the joint provided by a fine bal-
ance of pairs of forces. In addition, other studies
highlighted that the integrity of the subscapularis ten-
don plays a key role to reduce recurrences of rotator

Arthroscopic repair of the subscapularis tendon: indications, limits and technical features

Arthroscopic repair of the subscapularis tendon can be performed with the patient in lateral or beach-chair position. Arthroscopy allows a complete visualization of intra-articular aspects of the joint. Other features are also recommended: 1) The so-called "posterior lever push": the assistant applies a lever from anterior to posterior to better visualize the tendon and the extent of the lesion. 2) The internal rotation of the arm may better expose the tendon tear. 3) The use of an additional 70°arthroscope may also improve the joint view. Paribelli also introduced an approach to the joint through the sub-acromial space to visualize and assess the axillary nerve.

The approach to the subscapularis tendon is mandatory to carefully assess the long head of the biceps. Frequently involved in patients with subscapularis tendon tears, the LHB may be unstable at the pulley, completely or partially degenerated, and torn. A LHB tenotomy is indicated in most patients when necessary. A functional tenodesis at the groove may be undergone in young active patients, before or after the subscapularis tendon repair. We prefer to perform first the tenodesis at the biceps groove. Rotator cuff or labral tears following a trauma should be addressed concomitantly.

Coracoplasty and release/opening of the rotator interval may be performed. It is indicated in patients with coracoid impingement and related severe restriction of the subcoracoid space. This procedure is expected to induce a great release of local growth factors, as observed after acromioplasty. It is necessary to make an anterior-superior working portal by evaluating the optimal direction of the suture anchor position using a spinal needle pointing the footprint of the subscapularis tendon ("deadman angle" / 45° inclination).

Release of the adhesions is also important, especially when the lesions are retracted. It can be anterior, between the coracoids and the subscapularis tendon, or posterior, between the glenoid and the subscapularis tendon. However, undertaking a medial release through surrounding neuro-vascular structures may be controversial but, when performed, radiofrequencies should be done. Once the subscapularis tear has been identified, the retracted tendon can be loaded with a traction wire that may temporary favor the retraction of the tendon over the footprint, and assess accurately the tendon elasticity to repair it with a physiological tension.

Then, the footprint is prepared using the same principles adopted to repair the rotator cuff. The bone surface is cautiously decorticated and the footprint and subchondral bone exposure should be "medialized" up to 7 mm when lesion are retracted. At this stage, microfractures may improve the biological response at the bone-tendon interface.

Anchors (absorbable or non-absorbable) have to be placed and used in the same fashion of those implanted for rotator cuff repair. Biomechanically, it is advisable to use an anchor for each square centimeter of the bare footprint area: a single anchor may be usually used to complete the repair in almost all instances. As already reported in rotator cuff surgery, a double row repair is proven to be biomechanically advantageous in terms of strength and load to failure. Knotless anchors or bridging sutures can be alternatively used. The same tools used to repair the rotator cuff may be used to pass the sutures, paying attention that the sub-coracoid space is far narrower than the sub-acromial space. Double layer and splitting tears need to be addressed using small instruments which pass within the tendon itself without increasing the lesion neither compromising the primary stability of the repair. In partial tears, instrumental and arthroscopic diagnosis improve sensitivity and specificity of diagnosis, allowing to undertake a transtendineous repair similarly to what is made in "PASTA" lesions of the rotator cuff (Figs. 1-6).

Figure 1. Lesion of the subscapularis tendon: releasing the adhesions.

Figure 2. Inserting the anchor in a double anchor subscapularis tendon repair.
Results of isolated arthroscopic repair reported in peer reviewed Literature are summarized in Table 1.

Limits of arthroscopic repair

Limitation to repair arthroscopically a tear are the extent or grade of the lesion, the tissue retraction and the quality of the tendon itself. In some instances, the procedure has to be converted into an open procedure to reduce the extent of tissue infiltration, frequent in arthroscopy. The main limit to repair the subscapularis tendon is the extension of the lesion. Open surgery is indicated for management of extra-articular lesions or tears involving the myotendinous portion. In these cases, an anatomical repair is not mandatory as it provides a tenodesis effect, eventually achieved using augmentation with autologous or eterologous tendon grafts, or with muscle-tendon transfers (i.e. the pectoralis major).

Different tissue engineered biomaterials have been introduced for augmentation, using a combination of principles of engineering and biology: artificial polymers, biodegradable films, and biomaterials derived from animals or human. Synthetic scaffolds come from chemical compounds to better control both chemical and physical properties and confer relatively stronger mechanical strength and consistency.

Postoperative care and rehabilitation

Rehabilitation of subscapularis tears follows the same principles of rotator cuff rehabilitation. Specifically, brace for 3 to 6 weeks, early or delayed (after 3-4 weeks) passive assisted motion; inhibition of external rotation for 6 weeks, strengthening activities after 3 months and return to manual work and sports after at least 4-6 months.

In general, the rehabilitation program should carefully consider the extent of the tissue retraction and the tendon condition in terms of resistance and elasticity.
## Table 1. Results of isolated arthroscopic subscapularis repair - I part

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of Study</th>
<th>Level of Evidence</th>
<th>n° Patients</th>
<th>Mean Age</th>
<th>Gender (Men)</th>
<th>Dominant Extremity</th>
<th>% Trauma</th>
<th>Mean Time to Surgery</th>
<th>Tear Type</th>
<th>Repair Technique</th>
<th>Status of LHB</th>
<th>Concomitant Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanz et al. (2013)</td>
<td>Retrospective</td>
<td>IV</td>
<td>52</td>
<td>62 (45-81)</td>
<td>38 (82%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Lafosse type III and type IV</td>
<td>Anchors (arthroscopic)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Toussaint et al. (2012)</td>
<td>Prospective</td>
<td>III</td>
<td>35</td>
<td>58.4 (37-81)</td>
<td>66%</td>
<td>Right 72%</td>
<td>Single 50%, repeated 9%</td>
<td>-</td>
<td>UT tear (4); LT tear (6); CT tear (12)</td>
<td>Anchors (arthroscopic)</td>
<td>-</td>
<td>Ts 66%; Ty 100%</td>
</tr>
<tr>
<td>Josserand et al. (2012)</td>
<td>Retrospective</td>
<td>IV</td>
<td>22</td>
<td>54.7 (46-74)</td>
<td>20 (91%)</td>
<td>14 (64%)</td>
<td>59%</td>
<td>-</td>
<td>UT tear (4); LT tear (6); CT tear (12)</td>
<td>Anchors (arthroscopic)</td>
<td>D (18); N (4)</td>
<td>Ts (19); Ty (3)</td>
</tr>
<tr>
<td>Heikenfeld et al. (2012)</td>
<td>Prospective</td>
<td>IV</td>
<td>20</td>
<td>42 (31-56)</td>
<td>18 (90%)</td>
<td>16 (80%)</td>
<td>19 (100%)</td>
<td>6.7 mo. (0-18)</td>
<td>UT tear (10); LT tear (7); CT tear (3)</td>
<td>Anchors (arthroscopic)</td>
<td>PT (12); R (1)</td>
<td>-</td>
</tr>
<tr>
<td>Bartl et al. (2011)</td>
<td>Prospective</td>
<td>IV</td>
<td>21</td>
<td>44 (18-61)</td>
<td>16 (76.2%)</td>
<td>51 (71%)</td>
<td>91</td>
<td>6 mo. (0.2-14)</td>
<td>UT tear (4); LT tear (10); CT tear (7)</td>
<td>Anchors (arthroscopic)</td>
<td>N (6); D (3); PT (7); R (2)</td>
<td>-</td>
</tr>
<tr>
<td>Lafosse et al. (2007)</td>
<td>Prospective</td>
<td>IV</td>
<td>17</td>
<td>47 (29-59)</td>
<td>13 (76.5)</td>
<td>16 (94%)</td>
<td>77%</td>
<td>24 mo. (3-44)</td>
<td>PT tear (2); UT tear (4); LT tear (7); CT tear (4)</td>
<td>Anchors (arthroscopic)</td>
<td>-</td>
<td>Ts (11)</td>
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<tr>
<td>Kim et al. (2005)</td>
<td>Retrospective</td>
<td>IV</td>
<td>29</td>
<td>54 (41-65)</td>
<td>21 (72%)</td>
<td>-</td>
<td>21%</td>
<td>9 mo. (6-17)</td>
<td>UT tear (29)</td>
<td>Anchors (arthroscopic)</td>
<td>PT (15); D (13); N (16)</td>
<td>-</td>
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<tr>
<td>Bennet (2003)</td>
<td>Prospective</td>
<td>IV</td>
<td>8</td>
<td>57 (32-76)</td>
<td>5 (62.5%)</td>
<td>8 (100%)</td>
<td>-</td>
<td>-</td>
<td>PT tear (2); CT tear (6)</td>
<td>Anchors (arthroscopic)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Abbreviations. CT: complete tendon; D: dislocated; DC: excision of distal clavicle; FT: full thickness; LHB: long head of biceps tendon; LT: tear extending to lower third of tendon; N: normal; PT: partial thickness; R: ruptured; Rc: recentered; S: subluxated; Th: thickened; TO: transosseous; Ts: tenodesis; TT: transtendon repair; Ty: tenotomy; UT: upper-third tear.
## Results of arthroscopic subscapularis repair - II part

<table>
<thead>
<tr>
<th></th>
<th>SCORE pre-op</th>
<th>SATISFACTION</th>
<th>BELLY-PRESS TEST pre-op</th>
<th>Press Test post-op</th>
<th>LIFT-OFF TEST pre-op</th>
<th>Lift-Off Test post-op</th>
<th>POST-OP</th>
<th>COMPLICATIONS</th>
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</thead>
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<tr>
<td>Lanz et al.</td>
<td>46.4</td>
<td>98%</td>
<td>All positive</td>
<td>92%</td>
<td>All positive</td>
<td>92%</td>
<td>-</td>
<td>11% rerupture</td>
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<tr>
<td>(2013)</td>
<td>79.9</td>
<td></td>
<td>negative</td>
<td></td>
<td>negative</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Toussaint et al.</td>
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<td>17% positive</td>
<td></td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(2012)</td>
<td>74.1</td>
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<td>negative</td>
<td></td>
<td>9%</td>
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<td></td>
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<td>60% positive</td>
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<td>60%</td>
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<td></td>
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<td>23% normal</td>
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<td>9%</td>
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<tr>
<td>Josserand et al.</td>
<td>66.4</td>
<td></td>
<td>All positive</td>
<td>13%</td>
<td>23%</td>
<td>50%</td>
<td>-</td>
<td>14%</td>
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<tr>
<td>(2012)</td>
<td>(48-81)</td>
<td></td>
<td>negative</td>
<td></td>
<td>positive</td>
<td>normal thickness</td>
<td></td>
<td>(3 patients)</td>
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<td></td>
<td>(70-95)</td>
<td></td>
<td>12</td>
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<td>36%</td>
<td>13%</td>
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<td>with partial retear;</td>
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<td></td>
<td></td>
<td></td>
<td>(55%)</td>
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<td>asymmetric</td>
<td>6%</td>
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<td>45%</td>
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<td>4 (18%)</td>
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<td>asymmetric</td>
<td>31%</td>
<td></td>
<td>(10 patients)</td>
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<td>with localized</td>
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<td>16%</td>
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<td>41.3</td>
<td></td>
<td>All positive</td>
<td>16</td>
<td>23%</td>
<td>50%</td>
<td>89%</td>
<td>Retear (2)</td>
</tr>
<tr>
<td>(2012)</td>
<td>(21-52)</td>
<td></td>
<td>(89%)</td>
<td></td>
<td>positive</td>
<td>intact after 24 mo</td>
<td></td>
<td>24 mo.</td>
</tr>
<tr>
<td>Bart et al.</td>
<td>50.3</td>
<td></td>
<td>91%</td>
<td>16</td>
<td>13%</td>
<td>91%</td>
<td>-</td>
<td>Stiffness (1);</td>
</tr>
<tr>
<td>(2011)</td>
<td>(39-62)</td>
<td></td>
<td>(91%)</td>
<td></td>
<td>positive</td>
<td>intact (MRI)</td>
<td></td>
<td>Retear (1);</td>
</tr>
<tr>
<td></td>
<td>(65-98)</td>
<td></td>
<td>19 positive</td>
<td>5</td>
<td>16</td>
<td>1</td>
<td>-</td>
<td>LHB compl. (1)</td>
</tr>
<tr>
<td>Lafosse et al.</td>
<td>52</td>
<td></td>
<td>All positive</td>
<td>19</td>
<td>13</td>
<td>1</td>
<td>91%</td>
<td>Retear (1);</td>
</tr>
<tr>
<td>(2007)</td>
<td>84.9_</td>
<td></td>
<td>(94%)</td>
<td></td>
<td>positive</td>
<td>negative (after 24 mo)</td>
<td></td>
<td>LHB compl. (1)</td>
</tr>
<tr>
<td>(2007)</td>
<td>UCLA</td>
<td></td>
<td>5</td>
<td></td>
<td>1</td>
<td>positive</td>
<td></td>
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<tr>
<td>Kim et al.</td>
<td>23</td>
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<td>26 positive</td>
<td>-</td>
<td>26 positive</td>
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<td>no complications</td>
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<tr>
<td>(2005)</td>
<td>(22-25)</td>
<td></td>
<td>(96%)</td>
<td></td>
<td>positive</td>
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<td>Bennet et al.</td>
<td>43.3</td>
<td></td>
<td>48%</td>
<td>-</td>
<td>-</td>
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<tr>
<td>(2003)</td>
<td>(32-51)</td>
<td></td>
<td>(96%)</td>
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<td></td>
<td>74.2</td>
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<tr>
<td></td>
<td>(66-88)</td>
<td></td>
<td>(90-97)</td>
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<tr>
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<td>16.1</td>
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<td></td>
<td>(3-30)</td>
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<td>(48-100)</td>
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References